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The map which I have constructed of the Rio Negro and the Uaupés is from observations made during two ascents and descents of those rivers in the years 1850, 1851, and 1852. The only instruments I possessed were a prismatic compass, a pocket sextant, and a watch. With the former I took bearings of every point and island visible on my voyage, with sketches, embodying all the information I could obtain from the persons, well acquainted with the river, who accompanied me; and I constantly determined the variation of the needle, which was from 4¾° to 5° E. With the sextant I was enabled to obtain a few latitudes with tolerable accuracy. The position of Barra on the Rio Negro I have taken from Lieut. Smith, who determined it on his descent of the Amazon in the year 1835. The other extreme point, S. Carlos and the mouth of the Cassiquiare, I have taken from Humboldt and Schomburgk. For my positions between these points I have had to trust to the time occupied in the passage to the various stations, which I always accurately noted both in my ascents and descents, and thus obtained a *mean* which I think will not be very far from the truth. I also thus gained experience as to the rate of travelling in canoes under different circumstances, which I have had to depend upon in determining my distances on the Uaupés, where I had no other method of ascertaining the longitude of the extreme point reached.

The map, therefore, does not pretend to any minute accuracy in general positions, but only to give an idea of the physical features of a river still very imperfectly known.

The following are the most important distances on the Rio Negro:—

From its mouth	to the falls of Saõ Gabriel . .	710	miles.
,, ,,	to the entrance of the Cassiquiare .	900	,,
,, ,,	to its supposed source in long. 70° W.	1200	,,

XIX.—*Oceanic Currents, and their Connection with the proposed Central-America Canals.* By A. G. FINDLAY, F.R.G.S.

Read April 14, 1853.

WHILE almost every department of geographical science has of late made great advances through the exploration of zealous inquirers, one branch, that of the circulation of the waters of the earth, has remained nearly stationary. Although detached facts and numerous observations have been recorded, yet the generalisation of these data, and their reduction to a uniform system, remain nearly in the same state as when Major Rennell completed his "Investigation of the Currents of the Atlantic."

The history of currents, as a portion of geography, is comparatively new. Without including the knowledge of the Gulf Stream, which necessarily became known to the earliest voyagers to the West Indian settlements, the first contribution to the science was that by Major Rennell, "On the Agulhas Current," in 1778. This was succeeded, in 1793,* by his remarks on the current athwart the mouth of the English Channel, now known by his name. These memoirs contained the first elucidations of the system of oceanic circulation. It was about this period that chronometers began to be used in ships, and the means of ascertaining longitude were consequently first placed at the command of navigators; the comparatively rude astronomical instruments being quite incompetent to solve accurately this difficult problem. Without correct sea longitudes no estimate of currents can be formed. It will be observed that those elucidated by Major Rennell were on-shore currents, and the data on which they were established could be checked by land observations.

The only means of detecting currents in the open ocean is the comparison of a ship's reckoning with astronomical observation: unless the latter be good the former are worthless; and as the general drift of the water is in longitude, or from E. to W. or W. to E., the estimates are more difficult or inaccurate, as the means employed are less worthy of dependence; and it is tolerably certain that many of the older observations, perhaps many used by Rennell and others, are not trustworthy, being the scapegoat of errors of observation, leeway, bad steerage, heave of the sea, compass deviation, and many other elements which recent inquiries have enabled us to correct.

About the year 1810 Major Rennell commenced his current-charts of the Atlantic, at the suggestion of his friend, Mr. John Purdy, to whom hydrography is also largely indebted, and under whose editorship Major Rennell's work appeared in 1832. By this work, which embodied all previous knowledge, the following features were established on the then attainable data:—

Around the Cape of Good Hope the *Agulhas Current* ran strongly to the westward, following the line of soundings. It then ascended northwards along the W. coast of Africa to the Equator, whence it bore off to the W. under the name of the *Main Equatorial Current*. To the S. of the Agulhas Current a *Southern Connecting Current* set eastward across the South Atlantic into the Indian Ocean, between lat. 30° and 40° S., established chiefly on the observations of Captain (now Admiral Sir Francis) Beaufort. That all across the South Atlantic the *Drift Current* of the S.E. trade wind set on to the coast of Brazil, which, with the stronger force of the equatorial portion, ran to the southward,

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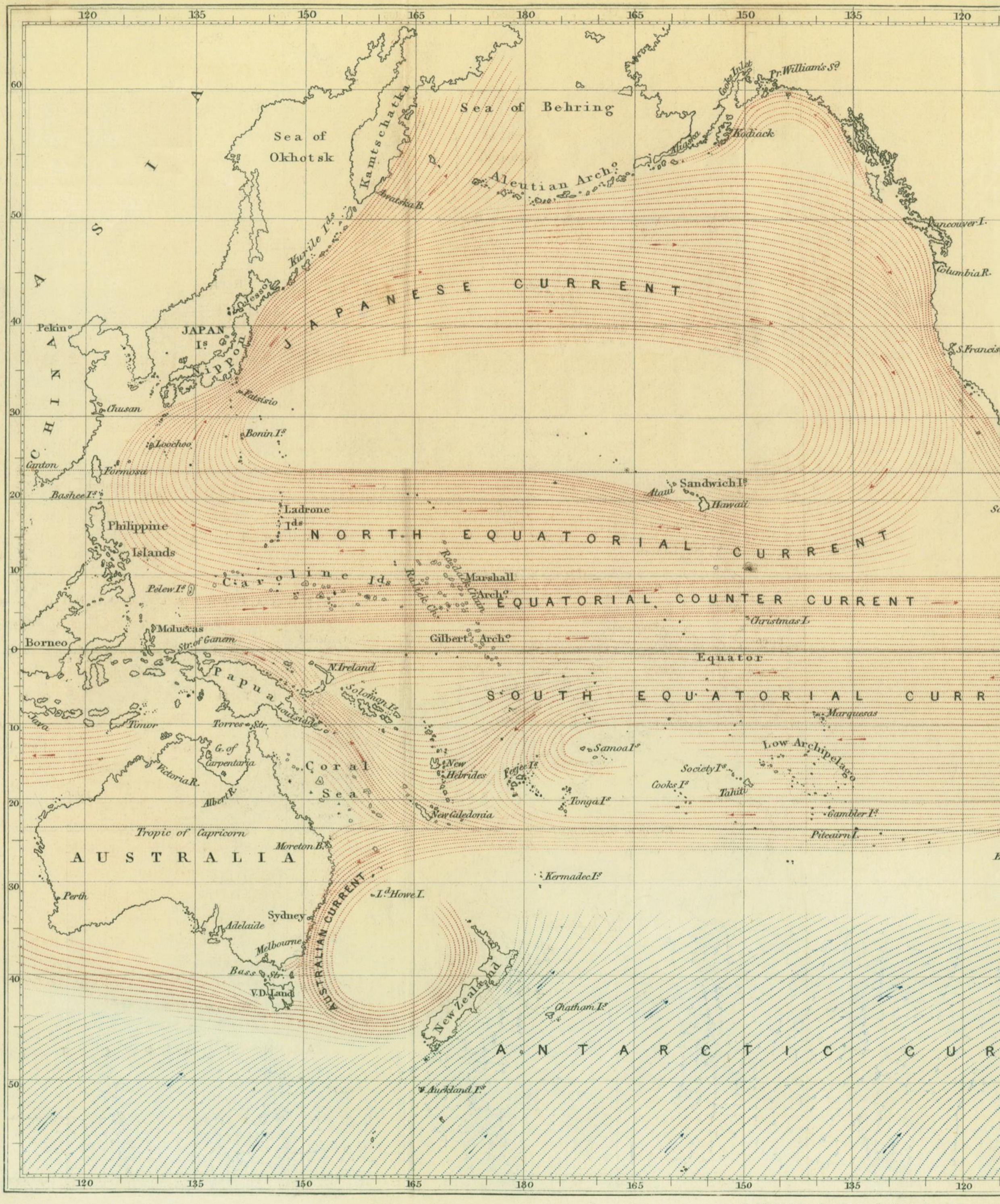
* Phil. Trans., lxxxiii. (1793), p. 182, and cv. (1815), p. 182.



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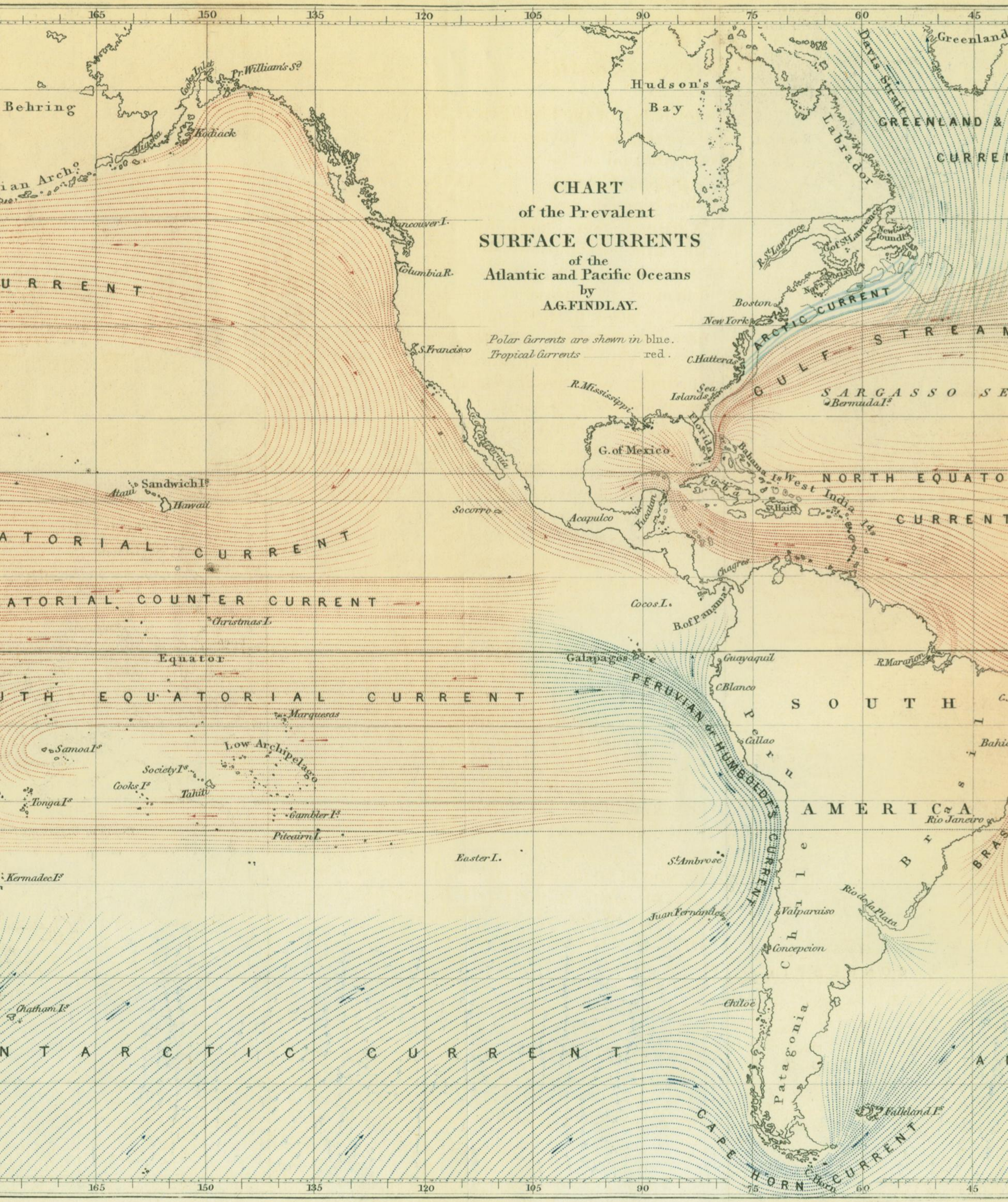
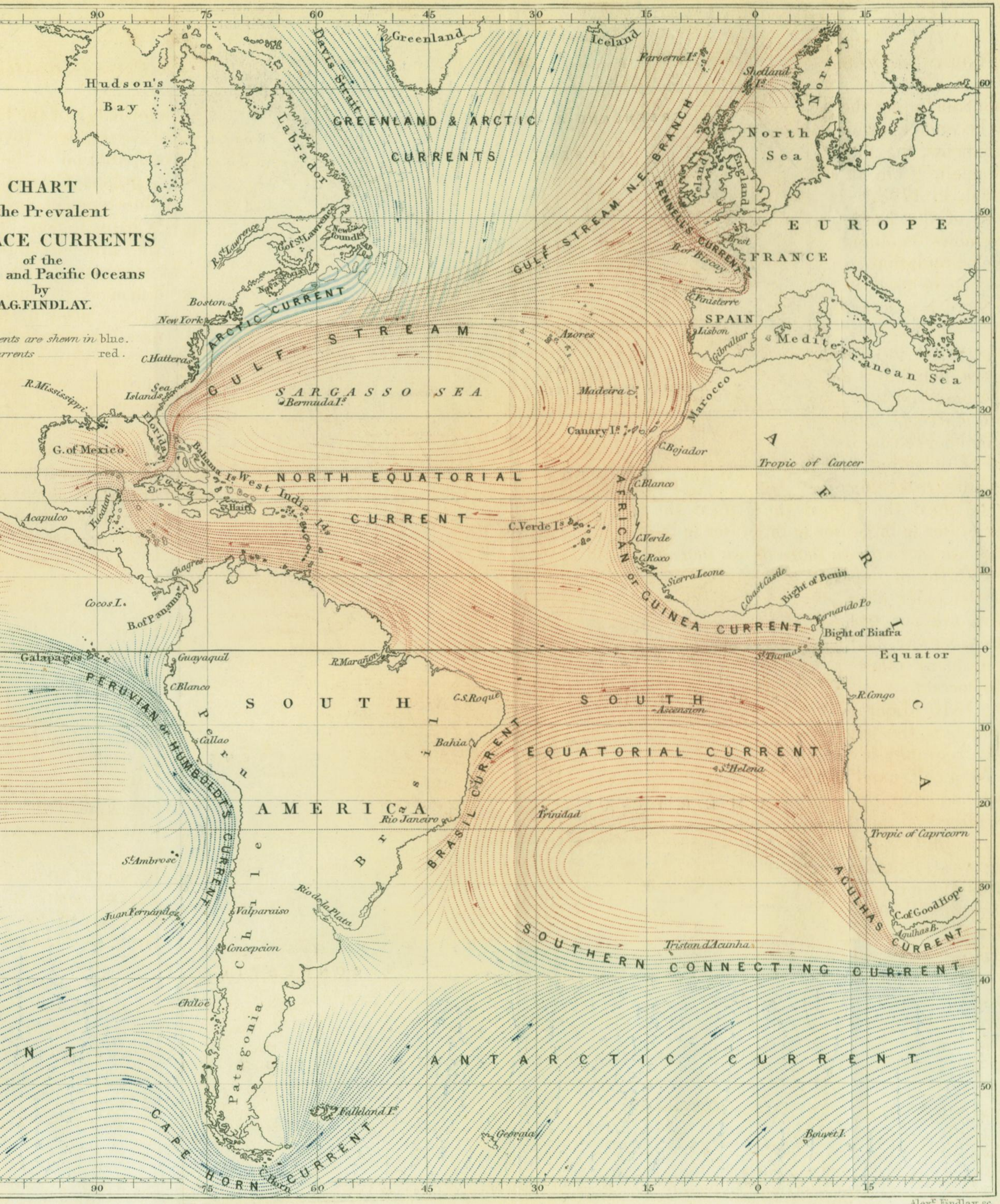


CHART
of the Prevalent
SURFACE CURRENTS
of the
Atlantic and Pacific Oceans
by
A.G. FINDLAY.

Polar Currents are shewn in blue.
Tropical Currents red.

Published for the Journal of the Royal Geographical Society, by John Murray, Albemarle Street, London 1853.



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forming the *Brazil Current*, which was intersected by the outfall of the Rio de la Plata. The *Main Equatorial Current* proceeded on to Cape San Roque, and then strongly towards the West Indies, while a portion, or the *North-west Equatorial Stream*, ran slowly to the N.W., which current he was unable satisfactorily to explain. The *Equatorial Stream*, entering the Caribbean Sea, passed between Cuba and Yucatan, entered the Mexican Gulf, and, raising its level, emerged in the well-known *Gulf Stream*. This famous current, after a course of 3000 miles, gradually weakened in velocity, was finally lost, about the Azores, in the *Sargasso* or *Weedy Sea*.

It will be observed that this arrangement makes all the streams set *into* this space on the parallel of about 30°. Proceeding farther N. we find that the '*Thwart Channel Current* (or Rennell's Current) was attributed to the continuance of westerly winds propelling the waters into the Bay of Biscay, which thence ran strongly out to N.W. To the N.W. the Arctic Current, bearing icebergs, met with and joined the Gulf Stream near the Grand Banks, and the *North Atlantic Current*, a very weak stream, between Labrador and Britain, setting eastward, was supposed to be the accumulation of the Arctic and Equatorial waters. This "Head of the Atlantic" found an outlet in the *North African and Guinea Current*, a stream setting southwards between the Azores, Africa, and Spain, which, however, S. of Cape Roxo, was very undefined, and thence, setting eastward along the coast of Guinea—as exemplified by Colonel Sabine—to Fernando Po, where it met with the *South Atlantic Current*. Indulgence is requested for this recapitulation of what is well known; but in applying this system to the opposite hemisphere, we are enabled to supply some of the deficiencies in this.

Such was the state of our knowledge, as Rennell left it to us. It will be seen that there are several difficulties to be encountered. In the first place, the waters constantly setting *into* the Sargasso Sea could not be reconciled with theory. The origin and continuance of the *Guinea Current* are anomalous, and the direction and termination of the *Arctic Current* are not satisfactorily traced. Commencing from the N., we find that the *Arctic Current*, setting southwards along the E. face of Labrador and Newfoundland, turns along the American coast in soundings *against* the course of the Gulf Stream, and is probably quite stopped by the projection of Cape Hatteras. This very singular current was first properly explained by Mr. W. C. Redfield, in 1838.* Its other features have been elicited by the operations connected with the United States' Coast Survey. It appears that the Gulf Stream closes in with the land at Cape Hatteras, and in its progress to the N.N.E. maintains on its *inner* side a nearly perpendicular wall of warm water in contact with the cold Arctic current flowing southward.* This fact of the non-blending of the warm tropical with the cold Arctic waters in juxtaposition, as is evidenced farther to the north-eastward, in passing the Newfoundland Banks, gives great weight to the suggestion made by Mr. Redfield, that the Arctic current really passes *under* the Gulf Stream, as manifested by the icebergs which are brought into its warm waters, and then left when the stream becomes too deep for their former transport to affect them.

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* Remarks on the United States Expl. Exped., Am. Phil. Soc. 1843.

Another feature of the Gulf Stream is elicited by the observations of Commanders G. M. and R. Bache, Davis, and Lee, U.S.N., that off Cape Hatteras there is a DOUBLE *gulf stream*, or rather that there is an easterly and parallel branch to the main stream.†

Of the origin of this bifurcation, the following suggestion is offered. That portion of the Equatorial Current which enters the Caribbean Sea passes out through the Strait of Florida, in the well-known current; but that portion, embracing an extent of eight to nine degrees of latitude to the northward of this, would pass northward of Porto Rico, strike the Bahamas, and, being thence deflected northwards, will run parallel to the main stream, and thus cause the double stream in question.

In this part of the ocean there are some singular phenomena in the currents, not manifest on the surface, which brings us to an important section of the subject—that of deep-seated or *submarine* currents.

In the early history of the development of currents, only those were dealt with or suspected which were *superficial* and evident from their effect on a ship's course ; later inquiries have penetrated the surface, and developed new features. Among other experiments on this point, those by Lieut. J. C. Walsh, U.S.N., made in May, 1850, are very interesting, and bear upon the circulation of this part of the ocean.‡ A logship of the usual form, but with a quadrantal arc of at least 4 feet, was heavily loaded in order to make it sink upright, and attached to a line of 126 fathoms. This line was attached to a barrega to float, and this to the usual log-line. The surface-current being ascertained, the apparatus was sunk, and was drifted in the direction, and with the velocity of the current, at the depth of 126 fathoms. The "Taney" being nearly midway between Bermuda and Porto

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* Report of Prof. A. D. Bache, Superintendent U. S. Coast Survey, to the Senate, 1848, p. 41.

† Report to U. S. Senate, Nov. 1848, p. 39.

‡ Washington Herald, Nov. 9, 1850.

Rico, on four consecutive days these trials were made, as shown on the diagram exhibited—the *red* arrows in the direction and proportionate length to the surface-current, and the *blue* arrows to those of the submarine current. Referring this to the chart, it will be seen that these indicate a sort of eddy, in which waters from each direction are by turns dominant.

Rennell has presumed that the Gulf Stream ceased to exist as an independent current in the vicinity of the Azores,* and that it is here lost in the Sargasso Sea, which he makes to extend meridionally from lat. 40° to 20°, in long. 40° W. But although some exceptions may be found among the drifts of the Azore Islands, yet the charts of Rennell, analogy, and many other and later observations, will demonstrate that its onward movement does not rest here. It may, perhaps, lose its characteristics as a *weed-bearing* stream, but a portion of it is propelled perhaps by the westerly winds towards the Bay of Biscay, and hence, forming the *temporary Rennell's current* farther northward, reaches the western coast of Ireland, and, by its comparatively high temperature, and the prevailing winds passing over it, causes the climate of this country to be a marked contrast to that of Labrador on the opposite side of the Atlantic—an advantage which some have supposed to be threatened by the intended Central American Isthmus Canal, which would let the Gulf Stream out into the Pacific. This amenity of climate is perhaps still more remarkable in the corn-growing coasts of Norway, as compared with the ice-bound shores of Greenland on the same parallel.† Still farther northward we have evidence of this warm current in the comparative amenity of the climate of the North Cape of Europe, and it is fair to infer that a considerable portion of heated water, which *can* only be derived from the Gulf Stream, passes on to the *polar basin* south-eastward of the southern Arctic drift. A remarkable similarity between this portion of the Atlantic and the part at the head of the N. Pacific is pointed out in Dove's recent work, "Verbreitung der Wärme."

As stated above, the Gulf Stream does not stop at the Azores; the portion which is not diverted to the N.E., passes S.E. towards Madeira, and striking on the shores of Marocco, has obtained for that coast a sad notoriety from the numerous shipwrecks caused by its unsuspected influence. In thus tracing the continuity of the Gulf Stream, enhanced in volume by the masses of surface water obeying the direction of the prevalent westerly winds, we obtain a very satisfactory cause for the North African current, whose origin and termination do not appear to have been well defined by Rennell. By him it is made to follow the *whole* W. coast of Africa to the Bight of Biafra as the *Guinea* current; but any mode of reasoning we may adopt would direct us to the fact, that *before* arriving at the Cape Verdes, it would trend off to the S.S.W. and S.W., the direction of the trade-winds in this part. From multiplied observation, we find that such is the fact; and, moreover, we are informed by the Baron Roussin, that the usual currents are completely changed on passing Cape Roxo. This portion of the Atlantic is considered by Rennell as a critical point, both in respect of winds and currents, the former having a periodicity similar to the monsoons of the Indian Ocean.

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* Investigation, p. 27.

† Dr. Shaw has just informed me that a warm stream, coming from the S., runs along the W. coast of Iceland. *See* a paper by Captain C. Irminger of the Danish Navy on "Havets Strömninger" in the "Archiv for Sövaesenet." Copenhagen, 1853.

Particular attention is requested to this portion, because it is one of the objects of this paper to point out an origin, not hitherto suspected, for this *Guinea* current, and which is still more manifest in a *corresponding current in the Pacific, which has an important bearing on the projected Central American Canal.*

The Guinea current is a *portion of the Equatorial Stream itself* here reflected, and coming from the westward, between lats. 5° and 10° N., from about the meridian of 28° or 30° W. It is, in fact, a WARM *current*, the North African current being comparatively COLD, there being a variation of about 10° Fahr. in the temperature of the ocean N. and S. of Cape Verde. In support of this, the charts and work of Rennell, the remarks of Horsburgh, and of many other instances, may be cited.

The main body of the *North African Current* turns to the S.S.W. and S.W., and then to the W., joining the Equatorial Stream; and the circulation is thus *around* the Sea of Sargasso—thus named from the *fucus natans* or gulf weed, a berry-bearing seaweed, so called by the Portuguese from "sargaçao," wild grapes—which lies on the parallel of 30°, almost across the Atlantic, the weed being found in all that space, and which is only affected by those partial drifts caused by the varying winds passing over it.

The circulation of the surface waters of the North Atlantic around this central space seems to be thus satisfactorily explained; and also the increase of waters brought into it by the *Arctic Current* is compensated for by the outlet *along the Norwegian coast.* A somewhat analogous process is going on in the South Atlantic. The waters circulate southward and eastward on the western side, with a high abnormal temperature, in the parallel of 30°; but the arrangement of land and ocean here allows the slow *cold* antarctic drift to flow northward and eastward with a less manifest effect than is observed in the northern polar current; nevertheless, it transports icebergs nearly as high as the latitude of the Cape of Good Hope.

In treating of the currents of the Pacific, we enter upon a comparatively new subject—one upon which little has been written; and that little certainly not satisfactory, nor confirmed by more extended observations.

Previous to detailing the phenomena of its currents, it may be asserted that the waters of the Pacific do not appear to move with that velocity nor apparent regularity that they do in the North Atlantic. Perhaps this may arise from the want of more extended and combined observations; or it is probable that the greater mass of waters, uninterrupted by land, opposes collectively a greater resistance to the action of the winds, which in themselves also appear to be less regular, and which are believed to be here the chief agent in the formation of surface currents.

Commencing from the southwards, we find the northward drift from the antarctic regions, at least permanent during the southern spring, August to October, transporting icebergs into a warmer latitude. We have no extended data or observations by which its velocity, exact duration, or direction can be estimated, which is more to be regretted, as it is a part of the ocean which probably offers some great advantages for the homeward track of vessels from Australia.

This current appears to come down to lat. 33° or 34°, with a velocity of 10 to 35 miles per day, and is analogous to the *Southern Connecting Current* in the Atlantic; but from the greater projection of the American continent it does not terminate in the same way, but, as has been demonstrated by Duperrey, strikes the coast of Patagonia or Chile, in an easterly direction about the parallel of Chiloe. This *cold* stream now divides into N. and S. —the southern branch forming the *Cape Horn Current*, the existence of which was once questioned, but which has been thoroughly established by the specific observations of the lamented Capt. Henry Foster.* Subsequent experiments have been remarkably uniform in their indications of this easterly set round the Cape, and carrying the drift-wood, &c., of Tierra del Fuego far beyond the Falkland Islands.

The other branch of this cold antarctic current is remarkable, and was first fully described by Humboldt in the autumn of 1802,† though its effects were known to the Spaniards soon after their conquest, as they used to, and still continue to cool their drinking vessels in its frigid waters in the Bay of Callao. Peru is also indebted to it for a cooler climate than its geographical position and natural character would otherwise accord to it. The remarkable difference in the ocean temperature on each side of South

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* Voyage of the Chanticleer, App. vol. ii. pp. 268-273.

† Berghaus, Physikalischer Atlas.

America is well exemplified in the diagram of the voyage of the 'La Vénus' frigate.

This mighty current is not a mere superficial movement, for it has been demonstrated by M. de Tessan to be above 973 fathoms deep in one portion of its course. In its progress N. it of course gradually acquires heat, but at Callao it is 14° Fahr. below the normal temperature. Still farther to the N., at Payta and Cape Blanco, it is 10° and 12° beneath the heat of the adjacent currents. Its western limit is not well-defined; but it appears, in some portions of its course, gradually to merge into the warmer waters of the adjacent ocean.

A counter current sets at times *inside* this stream, as is very usually the case in other parts of the world; here it was first noticed by Mr. Lartigue in the 'La Clorinde' in 1822-3.*

The Peruvian, or *Humboldt's Current,* as it has been termed, follows the direction of the coast as far as Cape Blanco, where it assumes a new direction, bearing off to the N.W. and W.N.W. towards, and S. of, the Galápagos. Hereabout the system of currents is most remarkable, and has a most important bearing upon the primary object of this paper.

The cold Peruvian Current, it has been said, is totally deflected at Cape Blanco.† This is not strictly and at all times the case. It sometimes sets round the coast to the northward, to the E. of the Isla del Rey, in the Bay of Panamá, and affords great facilities for working up to that anchorage. At other times and during strong N. winds this current is reversed. After passing Cape Blanco it sets over towards the Galápagos, and causes here some singular effects. There seems to be a constant struggle between these cold and the very warm tropical waters which set into this space. Colnett mentions some remarkable veins of current near this Archipelago, the edges of which abounded with animal life,‡ and hereabout was the greatest whaling-station in the Pacific. Captain FitzRoy says that in October, 1837, when the 'Beagle' was here, on one side of Albemarle Island the surface-water was found to be 80° Fahr., and on the other side it was less than 60°§ —a surprising difference in the Pacific, where the variations of temperature are usually within narrow limits. The low temperature of this current has one remarkable effect here, in the absence of all coral reefs around the Galápagos, as shown by Mr. Dana, as might be expected from its position. The waters are too cold for the zoophytes.||

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* Description de la Côte du Pérou, 1827, p. 20.

† Berghaus, Länder und Volkerkunde, vol. i. p. 587.

‡ Voyage to the South Seas, pp. 45-6.

§ Voyages of the Adventure and Beagle, vol. ii. p. 505.

|| Narrative of the U. S. Exploring Expedition, vol. v. p. 471.

Having brought the antarctic waters up to the equator, they must hence be considered as forming a portion of that *great westerly movement* of the ocean *within the tropics*, known as the *Great Equatorial Current.*

In its physical relations the Pacific does not bear the same aspect as the Atlantic. The widely different arrangement of the land, caused by the easterly projection of the South American continent, so far confines the revolving action of the currents to the northern portion of that ocean, and makes the Gulf Stream the chief current. In the Pacific, on the contrary, the great breadth of ocean is left unimpeded by land, and a much greater mass of water must be set in motion to become evident as an independent current. If it can be proved that the surface action of the sea is due to the force and action of the wind, we can the more readily understand how that the currents will not be so strongly marked as in the Atlantic—a fact more evident when it is remembered that the regular trade-winds are far from being as constant in the Pacific, especially in its western portion, as they appear to be in the Atlantic. In some portions these winds partake of the character of the monsoons. In the North Pacific especially there appears to be a thermal system *apart* from any connection with the adjacent portion. The currents in the Atlantic attain their maximum velocity and heat in the western portion. In the Pacific it is on the eastern side they are most marked, from the reason, probably, that the winds have not sufficient force and regularity to cause that steady movement in the western portion, which are so evident on the opposite side of the continent, whence we find many anomalies difficult to be accounted for at present.

Resuming the actual currents—the *Great Equatorial Stream*, or the southern branch of it, has its initial impulse from the Peruvian Current. It follows the general direction of the trade-winds, or to the N. of W.; and its southern limit, beyond the influence of the continent, is at lat. 26° S. The Peruvian Current, however, does not extend its influence to nearly this parallel, as M. de Tessan's observations* make its S. limits in long. 107° 50′ W. at 9° 20′ S. To the S. and S.E. of this the westerly drift appears to be by no means constant, for neither Wilkes nor Lütke found any current between the American coast and the meridian of Tahiti. It is even stated that they flow in an opposite direction. and Berghaus has denominated an easterly set in lat. 21° to 26° S. the *Mentor's Counter Current*, from having been found by that ship October, 1823. This certainly is curious, if constant; but it may be only a partial drift, consequent upon some change in the direction of the wind. A current cannot be established by a single observation. Neither the observations of Kotzebue, La Pérouse, nor Lütke, confirm the existence of this current.

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* Voyage autour du Monde, &c., tome ix. p. 347.

Whatever individual exceptions may be found as to the general set of the waters in the South Pacific, there can be no doubt that they obey the same laws as in other portions of the ocean, less evident in its southern portion, for Captain Beechey's experience in the 'Blossom' fixed the mean velocity at 9 miles per day on its southern border, and between 18° S. and 4° N., at 16·5 miles per day.

In the vicinity of the Archipelagoes, on the souther portion of this current, there are many difficulties. Their regularity seems to be greatly impeded; and, as in the case of the trade-winds, they seem at times, and without sufficient apparent cause, to set directly opposite to what may be considered as the normal direction. Among the Low Archipelago this is manifest at times, though it sets usually to the westward, at a mean of from 5 to 25 miles per day. The Society Islands have some remarkable variations in this respect, but it was shown by Captain Cook, in his first voyage, that the trade-wind cannot be considered constant here to the S. of lat. 20° S., and that S.W. gales frequently prevail to the S. of this, causing the current and swell to set on to the leeward side of the islands. This S.W. swell is almost constant at the Tonga group. To the same origin we may attribute the very singular circumstance stated by Wilkes, that a continual current to the EAST of about 12 miles a-day exists among the islands of the Feejee group. This he attributes to the existence of cold, submarine currents. The same authority also states that, on the S. side of the Samoa or Navigator's group, the current generally prevails to the *eastward*, and to the westward on the N. side.[*] From the very high temperature of the ocean found in this part by the American expedition, there appears to be some peculiarity in the currents. Still farther westward, both Carteret and D'Entrecasteaux found a strong current to the westward at Santa Cruz Islands. At the Salomon Islands the current runs *eastward* during the period of the S.W. monsoon, or September to March; at other seasons it runs to the westward. The current, which has been called ***Rossel's Drift*** by Berghaus, sets strongly to the N.W., off the New Hebrides and New Caledonia. Off the N. coast of Papua the current, as far as known, runs permanently and strongly to the westward. D'Urville found it 58 miles in 48 hours.[†] There does not appear to be a corresponding set to westward beyond this; indeed, to the northward of the tropic, as far as Torres Strait, there does not appear to be any current.

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[*] Narrative, &c., vol. v. p. 472.

[†] Voyage de l'Astrolabe, vol. iv. p. 557.

The *Australian Current* is an exact equivalent to the Brazil Current in the Atlantic. A portion of the South Equatorial Current, S. of New Caledonia, is turned to the W.S.W., towards the Australian coast, down which it flows to southward, a warm stream, of the velocity of one or two miles an hour, and having, as is very usual, a counter current close in shore. This warm stream becomes very strong at the southern part of Australia, and thence bears more to the E. Lieutenant Jefferies, whose remarks do not entirely accord with those of the excellent Flinders, says that the current runs to southward in summer, and is reversed during the remainder of the year.* This current, which, on a minor scale, resembles the Gulf Stream, appears to circulate around the space between New Zealand and Australia, the whole of which space is maintained at a high abnormal temperature, in which there are no distinct currents, and in the still waters of which the food of the whale is, or has been, abundant, and forms the prolific "Middle Ground" of the New Zealand and Australian whalers.

There is one other current here which has not been connected with any other system: it is a warm drift, *to the S. of Van Diemen's Land*, mentioned by M. de Tessan as having been passed in La Vénus. It is 8° or 7° Fahr. above the surrounding waters.† It is perhaps the equivalent of the Southern Connecting Current of the Atlantic, and coming from the Indian Ocean.

The *Northern Equatorial Current* has, like the southern portion, many and considerable variations in its steadiness or constancy. Its northern limit is placed by Duperrey, at a mean, in lat. 24° N.

It has been argued by M. Babinet, upon the basis of Duperrey's observations, that, in the circulation of oceanic waters, their greatest force or velocity is at their outer limits: this force gradually diminishing within the area, leaving the central space not acted on by the circulatory movement, and which area would thus be, theoretically, of a higher temperature if polar streams should not add their cooling influence. This fact is well exemplified in the Atlantic Gulf Stream, and its perpendicular outward face, and the still eddy of the Sargasso Sea. In this North Equatorial Current, also, we find the greatest strength near the southern limits; and it may be doubted whether Duperrey's limit of 24° N. be not too high, as it is stated that there is not any very distinct current at the Sandwich Islands in 20° N. by Wilkes; but then this navigator lost the trades in 19° N.; and the valuable series of observations by Dr. Rooke demonstrate that the trades do prevail here, especially from April to October. *

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* Flinders' Voyage, vol. ii. pp. 282-286.

† Voyage de la Vénus, partie physique, vol. iv. p. 350.

The North Equatorial Current does not receive such a well-defined current at its eastern extreme as the Peruvian, which commences the southern branch, and there is a paucity of recorded observations respecting the temperature and set of the ocean between the Mexican coast and 130° W.; but it is very probable that the warm waters of the Equatorial Counter Current, setting easterly *into the Bight of the American Isthmus*, find an outlet to the northward, along the Mexican coast, for M. de Tessan found a very warm stream setting along the coast near Acapulco.

Respecting the currents around the Sandwich Islands, of course a few detached observations, such as we have at command, will not establish any systematic arrangement, but one fact will bear with great weight on it. The island of Atauai derives its name, according to Ellis, from "to light upon," or "to dry in the sun," which, the late king stated, arose either from its long droughts, or from the large pieces of timber washed on its shores. This drift of timber on its *N.E.* side is not uncommon, and Vancouver saw a noble canoe, 61½ feet long, formed out of a single *pine*-tree, which had been drifted on to the E. end of Atauai, without shake or bruise. There can be little doubt that this tree, and others also, came from the W. coast of America, indicating the set of currents presently alluded to.

Our remarks as to the further progress of the North Equatorial Current to the westward need be but few. On its southern border its velocity is considerable: Kotzebue was drifted by it beyond his control, through the Marshall Islands. At the Marianas the currents are subject to great variations, according to the observations of Freycinet and Golownin, rendering it more than probable that the westerly monsoon, which is felt here from June to October, may cause a reversion of the usual current. But it is certain that it predominates to the northward and westward beyond them. Similar remarks to those offered on the southern branch of the Equatorial Stream, between New Caledonia and Torres Strait, may be applied to the space between the Marianas and the Philippines; but the circulation of the waters is clearly manifest, as it runs strongly to the northward, on the eastern face of the last-named islands. We have thus brought the Great Central Drift of the Pacific from its eastern to its western limits; and although not many new facts are brought to bear on the subject, yet the indulgence of the Society is craved in this endeavour to give a connected view of the general phenomena of the Pacific at the present period of their greatly increasing importance.

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* Voyage de la Vénus, partie physique, vol. iv. pp. 452-4.

Hitherto published accounts of the Pacific have appeared to be very vague and unsatisfactory, and the attempt is made to place them on some better footing—to assimilate it to that on which the Atlantic currents are established. And it is here confidently stated that some very important branches of the subject have been entirely overlooked, or only slightly touched upon.

Two currents at least, of immense magnitude, and of the greatest importance in the future commerce of the Pacific, have not hitherto appeared on physical charts nor descriptions, and are placed *for the first time* on the chart before you. The first is a great belt of water, lying under the zone of equatorial calms between the trade-winds, which extends across the entire breadth of the Pacific. The data upon which this may be established will be cited presently, and is here named the *Equatorial Counter Current.* The second is a gulf stream of the Pacific, hinted at by M. de Tessan in 1837-44,* as existing in the central portion of the North Pacific, but which will be traced here to the coast of Japan, and thence named the *Japanese Current,* from the analogous relation to Florida and the Gulf Stream.

The *Japanese Current* is, like the Gulf Stream, a continuation of the Equatorial Drift. By a reference to the chart it will be seen that the Philippine Islands, which lie between the same parallels as the West India Islands, unlike them, offer an entire barrier to the main strength of the western drift. Were it not for this, or if a similar arrangement existed, we might expect that the coasts of Cochin China and China itself would present the same features as the S. and W. coasts of the United States, and that a very strong current would emerge between Formosa and the main. But the waters being diverted to the northward, run very strongly past the Babuyan Islands towards the coast of Japan. There is no doubt but that the changing effect of the monsoons greatly affects the set of the currents in this part in different seasons, but of the main drift there appears to be no doubt. The first evidence we shall offer is the *Japanese charts themselves.* On all of them, as shown by Von Siebold and Krusenstern, between Fatsisio and the S. part of Nippon, S. of the capital Jedo, an *easterly* current is marked, called the *Kuro-Siwo Stream,* or, as Krusenstern calls it, Kourosegawa, or the Current of the Black Gulf. Although its dimensions are here small—not more than 15 miles broad (between these islands)—it is stated that in " winter and spring it is difficult to navigate, but in summer and autumn vessels can pass it." This notice from such authority is important in this initial portion of its *easterly* set on the coast. On the eastern side of the Japan Islands the current is very strong. Captain King, who accompanied Cook, states that the 'Resolution' was set at least *four miles an hour* to the N.E. by N. in long. 141° and lat. 35° 43′; and, according to his observations, the current was 250 miles broad off this part of the Japanese coast.* Admiral Krusenstern was also set 2 miles an hour to E.N.E., at 70 leagues from land, in the parallels of 36° to 35½°. When the 'Nadiejeda' discovered the coast of Japan in lat. 31°, and particularly the southern part of the island of Sikokf, the current ran to N.E. 3¼ miles per hour.† A correspondent of the Chinese Repository (vol. xii.) states that he found the current to run 79 miles in 24 hours to N.N.E. off Jeddo.‡ Captain Broughton was on the E. coast of Japan during the months of November and July, and was constantly in a current which bore to the N.E. at 2 miles an hour. These authorities will suffice to show that the current here is nearly constant, and of a force comparable to the Gulf Stream. When it reaches the parallel of 40° N. we have a remarkable evidence of its existence. It is well known that the banks of Newfoundland are proverbial for their dense fogs. This arises, not from the fact of their being shoal water, but from the warm Gulf Stream transporting tropical heat into a frigid climate near them. The Japanese Current does this also. The whole of the coasts of Jesso, the Kurile Islands, and Kamtschatka are subject to dense fogs. Captain Beechey, on his route to Behring Strait, in June, 1826, entered these fogs in lat. 39°, in long. 163°, and their S. margin also in 39° N., in long. 155° E., in June, 1827. A warm current reaches the shores of Kamtschatka. M. de Tessan points this out, and attributes the mildness of the climate of the S.E. face of the peninsula, and its comparative freedom from ice in the bays and inlets, to the warm current he encountered in 'La Vénus.'§ It has a similar effect in forming the marked contrast between the inclement western shores of Japan and the much milder temperature of the eastern side. The circumstance of the wreck of a Japanese junk at the S. end of Kamtschatka in 1726 may be cited also in evidence.‖ The wrecks of Japanese junks are also recognised on the shore on the S. extremity of Kodiack. A Japanese junk reached, and anchored at Oahu in the Sandwich Islands, after dreadful suffering, in December, 1832, having been the sport of currents and winds.¶ A Japanese junk was wrecked near Cape Flattery, in Oregon, in 1833, as related by Washington Irving.

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* Voyage de la Vénus, partie physique, vol. iv. p. 348.

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* Cook's Last Voyage, vol. iii. pp. 404-5.

† Mémoires Hydrographiques, partie i., Introd. p. xx.

‡ *See* Chinese Commercial Guide, Canton, 1848, p. 118.

§ Voyage autour du Monde, vol. ii. pp. 37-40.

‖ Müller, p. 8.

¶ Hawaiian Spectator, vol. i. p. 296, quoted by Sir Edw. Belcher.

Captain Du Petit Thouars, in 'La Vénus,' in October, 1837, found an enormous difference in the temperature of the water between 42° and 45° N., in long. 156° to 164° W., amounting to 13° Fahr., in the course of three or four days. In long. 164° E. he found this sudden change to occur in lat. 40° or 41° N.* These last are positive evidences of tropical waters reaching this latitude, and apparently their heat is greater than that of the Atlantic Gulf Stream in the same parallel. The incidents of the Japanese junks are links in the chain where direct evidence is wanting; for it must be noticed that this part of the Pacific is almost a *mare incognitum;* but few passages have been made, or observations recorded, as to crossing its northern part.

Now, although there is no continued series of observations on this very important stream, yet, by taking it up in different portions of its course, and applying the same reasoning as in the phenomena of the North Atlantic in the same parallels, it may be confidently affirmed that ships passing from China towards Oregon, or California, or the western coasts of America, would find every advantage in pursuing a higher northern track than has been usual. In addition to its being a nearer approximation to the Great Circle, or shortest route, which, from San Francisco to China, takes up to 48° 5′, the winds will be probably found more favourable than in a lower latitude; and the consideration of this subject has a very important bearing upon the Central American Canals.

In connecting this stream with the area of circulation in the North Pacific there is little difficulty. The American Exploring Expedition found the current S.E. and southward strongly on the parallel of the Columbia River, and as far to the westward as 143° W. Farther S. the same currents were observed in the latitudes 30° to 35° N., as far as 128° W. The Dutch brig of war 'Koerier' also fell in with these S.S.E. currents in October, 1839, in lat. 37° N., long. 132° W., and carried them down to the tropic.† The observations of M. de Tessan would place the eastern limit of the warm water in about 127° W., off San Francisco.

Connecting these facts with that of the drift-wood floated, more than probably from the American coast, over to the Sandwich Islands, the circuit of the Pacific is made; and on the parallel of 30°, in the axis of revolution, we find the favourite fishing-ground of the whalers. Wilkes states that vast quantities of janthina, the soft mollusc of which is a food of the whale, were found on the verge of the trade, in 26° N. and 168° W.; and again, when in

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[*] Voyage de la Vénus, vol. ix. p. 348.

[†] Verhandelingen en Berigten door Tindal en Swart, 1852, No. i. p. 95.

30° N., in 180°, an immense collection of anatifa, another mollusc, was found lying in a line bearing W.S.W. and E.S.E., indicating the effect of current.* We do not find any notice of a similar production to the *fucus natans*, the place of which these mollusca evidently supply.

A portion of this area has been noticed as a vortex by Fleurieu, from the voyage of Marchand in 'La Solide;' but this voyage is not satisfactory for establishing currents.

Respecting the drift of the waters on the N.W. coast of America, above Sitka, it is stated that they circulate to the northward and westward as far as Prince William Sound, on the shores of which vast quantities of débris are found.† West of this, it sets to the southward, strongly at times to the eastward, of Kodiack. Whether this be only a shore current, which so usually is the reverse of that in the offing, or not, we have no means of determining absolutely. If not, it does not form any part of the circulation with the Japanese current; but temperature is one of the most important evidences of the origin of currents which so strongly influence climate; and, according to the valuable temperature-charts in Dove's "Verbreitung der Wärme," 1852, there is a remarkable coincidence, or rather exact similarity, between the normal and abnormal temperatures of the head of this great bay, and that of Norway, which lie on the same isothermal line, and in every month almost entirely coincide with each other, notwithstanding the difference of latitude—a similarity we must attribute to similar origins, the "Gulf Stream" in each ocean.

On the coast, between Monterey and the Columbia river, the current sets with great regularity, about half a knot per hour, to the southward, from March to October; in the opposite season it is variable.‡ Off the coast of Lower California, the current still bears to the southward, and there is frequently or usually a very strong outset from the Gulf of California. According to Capt. Worth, R.N., the currents off the coast of Central America are variable, *but almost always to the S.E.*—sometimes rather strong; but then there is at times a strong counter current setting close in shore, which affords the only facility for ships to work their way to the northward.

Having shown that the Peruvian Current sets its cold waters towards the Bay of Panamá, and that the currents down the coast of North America also set into the same bay, we have now to show that there is another and very extensive current also setting towards the same point.

The *Equatorial* COUNTER *Current*, which has been thus denominated from its relation to the great Equatorial Drift, might perhaps be properly named the "*Equatorial Current*," and the opposing streams on either side called the "*Tropical Streams.*"

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* Narrative, &c., vol. v. p. 109.

† Lütke, Voyage du Séniavine.

‡ Lieuts. M'Arthur and Bartlett, U.S.N., 1850.

This current is an EASTERLY stream, setting with a considerable velocity between the parallels of 4° or 5° to 10° N. lat. In one portion of its course only has it found its way into charts, and this from the observations of the Prussian ships, Mentor and Princess Louise, published by Berghaus.

Commencing with the extreme W., Krusenstern says, "During the S.W. monsoon, ships returning from China and proceeding by the Pacific Ocean towards the Strait of Ganem (at the W. end of Papua), do not generally go farther to the E. than the Pellew Islands; but if they do not pay great attention to this current they will be usually carried several degrees to the *E*." * This is a current between the equator and 6° N., frequently having a velocity of 20 leagues in 24 hours. In this part it is found farther S. than in the eastern portion, probably from the different relation of land and water, as in the Guinea Current.

Duperrey found this *E.* current in longitudes 137° and 148° E., between the equator and 8½° N., and also between 2° and 6° N., at 7° to 10° E. of Ualan. Lütke also had the current E. 13 miles per day, in lat. 3° N., when near Ualan. To the W. of this, between 5½° and 7° N., for 3 weeks in January, there was a constant easterly current of 8·3 miles per day, as a mean.† Capts. Hunter and Wilson also found it *E.*, to the southward of the Caroline Archipelago. In July, 1833, it was found to run to the E. 2 or 3 knots an hour, near the equator, for 15 days, in about longitude 175° E., and this during a fresh easterly wind.‡ In the Gilbert Archipelago, large trunks of trees are drifted on to the *W.* sides of the islands in S.W. winds, together with large lumps of resin similar to those found in the soil of New Zealand, which must all be transported by currents.§ In the longitudes of 167° to 150° W., with some exceptions, the ships of the United States' Exploring squadron found it setting a little N. of E., in Sept. to Nov., 1839. Capt. Scott, R.N., of H.M.S. Samarang, on Sept. 16, 1840, found it set 50 miles per day, N. 33° E., in lat. 6° 47′, long. 163° 13′ W. Capt. Beechey found it set N.N.E. 15 to 23 miles a day between the equator and 4° N., that is, to the S. of our present limits, on the meridian of 150° W. Among the most important series of observations recorded of the Pacific are those taken in the French frigate, La Vénus, under Capt. (the present Admiral) Du Petit Thouars, which have been frequently quoted here. The temperature of the air and ocean were taken every hour throughout the voyage. They crossed the track in question in June, 1838, about the meridian of 135° W. The observations show a considerable increase in the temperature, as might be expected, if our inferences be good; but, singular to say, there is no *direction* of the current recorded;* perhaps it was considered, if the set was *easterly*, that the observations were defective from their anomaly, and the transition from the steady westerly currents observed before and afterwards.

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* Mémoires Hydrographiques, part i. p. xv.

† Voyage du Séniavine, partie nautique, p. 186.

‡ Naut. Mag. 1843, p. 5.

§ Narrative U. S. Exploring Exped. vol. v. p. 105.

Between the meridians of 125° and 132° W., we have the authority of the several voyages made in the Prussian ships, Mentor and Princess Louise, for establishing this as an independent current, these observations extending it, in some cases, to 11° N., but not southward of 6°. Admiral Lütke also experienced the same on the meridian of 129° W., in May, 1827. In December, 1849, the Dutch brig of war, Koerier, crossed this track in long. 112° W., and found the *easterly* current commence in lat. $9\frac{3}{4}$° N., and with a velocity of from 25 to 35 miles per day; but on arriving at its southern limit, in lat. 4° N., she was drifted no less than 330 *miles in* 5 *consecutive days* to the N. by W., and northerly currents continued as far as lat. 1° S.† Capt. Sir Edward Belcher, in the Sulphur, at Clipperton Island, lat. 10° 17′ N., long. 109° 10′ W., says that the island was covered with sea-birds, which had been noticed in great numbers during the previous week at least 500 miles to the eastward. From this an *easterly* current may be inferred, as these birds generally keep its stream or tail course.‡

Capt. Beechey, on crossing from Acapulco southwards, in long. 99°, found an easterly current of 8 miles per day between that port and 8° N.; S. of this they flowed to westward. When Vancouver crossed on this track, in December, 1794, he had a westerly current of 30 miles a day, but between lat. 9° 27′ N. and Cocos Island the set was half a knot to southward; after this strong ripplings and great agitation, denoting a conflict of currents; and on making Cocos Island there was a strong current of $2\frac{1}{2}$ knots setting to the *E.* and *N.E.* Colnett found it setting strongly to the W.

Now, upon referring to the chart upon which most of these observations are placed—and it will be noticed that they are all, or almost all, drawn from recognized authorities,—the limits of this *new* current are in general well defined within the latitudes we have named, 5° and 10° N., and that this and other currents have a tendency TOWARD that one locality now looked upon with so much interest. It cannot be supposed, however, that they always set *into* the bight without some regular outlet; but this does not appear to have been detected as a SURFACE current, with which alone the navigator has to deal. The currents about Cocos Island are very violent, and perhaps uncertain, but of their *eastern* tendency, at times, there is no question. The only direction for an outlet which now suggests itself is indicated by the very warm current encountered by La Vénus, off Acapulco.

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* Voyage de la Vénus, partie physique, vol. iv.

† Verhandelingen, &c., door Tindal en Swart, 1852, pt. i. p. 97.

‡ Voyage of the Sulphur, vol. i. p. 256.

The current system which thus centres in the Bay of Panamá, by which term is here meant that great indentation of the American coast, of which Panamá Bay is the head, is most peculiar, and, as far as is known, unexampled; for the Bight of Biafra, although somewhat similar, is not entirely so. Their anomaly and difficulty have been rendered very evident by the history of voyages in this portion of the Pacific, and many sad tales of suffering may be told of ships leaving Panamá without a proper knowledge of the best route to be pursued. As a case in point may be mentioned that of "the barque Emily, of London, which sailed from Panamá for San Francisco, March 7th, 1852, and after being out ninety-five days, put into San Blas with 19 of the passengers *dead from starvation.* The remaining passengers were then transferred to the Archibald Gracie, and were sixty-five days more on their passage to San Francisco, during which 18 more of these unfortunate people died: the suffering endured is almost beyond description." Yet the route pursued, we believe, was that stated to be a proper one to Captain Basil Hall, by a local authority.* She steered a course which took her beyond the influence of the land-wind and shore-current, by which alone she could have made progress.

In endeavouring to trace these mighty operations to their origin, to connect effect with cause, we encounter several difficulties at the outset. But little is known of the powers of absorption of heat in the water of the open ocean; we do not know even its density accurately, and all experiments have probably placed the maximum of this too high. Colonel Sabine states its maximum density, as arising from temperature, at 42° Fahr., and Sir James Ross at 39·5°. This last observer places the points where the temperature is the same (39·5°) from the surface to the bottom of the ocean, in a mean latitude of 56° 26′ in the southern hemisphere. This is assumed from a series of experiments commenced on January 3, 1842, in lat. 66° 34′ S., when the temperature *increased* from 36° at the surface to 39·5° at 945 fathoms. Many experiments might be cited which show different results from this, at least on this side of the equator; but of its accuracy there can be no doubt. Nearer to the pole than this zone there will be colder water above this stratum of 39·5°, and toward the equator it will be warmer, so that we find this maximum density under the equator at the depth of 1200 fathoms. Sir Henry de la Beche estimates that this bed of cooler water forms an inclination towards the *pole* of 1 in 1723, and towards the *equator* of 1 in 1136. "So small an angle, with a change of temperature so gradual, could scarcely produce a lateral movement in the mass of ocean waters of geographical importance." To this source we cannot, therefore, attribute any origin of currents, which, besides, are chiefly in the opposite plane to meridional action which this would induce.

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* Extracts from a Journal, &c., pt. ii., Appendix i., No. xii.

Respecting the maximum density of water, Erman places sea-water at a temperature of 25°, Dr. Marcet at 22°, Colonel Sabine at 42°, and Sir James Ross at 39·5°; but at whatever point it is fixed hereafter, one thing at present is certain, that we can sink a sounding-weight to an enormous depth, and obtain submarine temperatures at a stratum which, if the density increased with the depth, would place it beyond possibility; but there is one difficulty in assuming that the *depth* is accurately measured by the length of line run out.

We have before shown, incontestably, that there are sub-surface streams of a very different nature to those evident by their effect on a ship. Supposing a sounding-line encountered one or more such streams, and it is tolerably certain that they will do so, the impact of a current on the sounding-line (supposing it to be 1-10th of an inch in diameter, the sectional area of 1000 fathoms is 50 square feet) must swerve the line greatly from the perpendicular; and should the weight reach the bottom, it will carry the line off the reel with *double the velocity of the current*, so that the sounding by wire, 5700 fathoms, by Lieutenant Walsh, U.S.N., or the still greater depth, 7706 fathoms, attained, or supposed to be attained, by Captain Denham,* is open to much doubt.

Temperatures supposed to be gained at great depths cannot be said to be absolutely accurate, for the depth actually reached must remain unknown; the pressure of the water may affect the bulbs of the thermometers—a point endeavoured to be rectified by the spiral of two metals employed by the Americans.

These remarks are made to show that, *as yet*, we know little or nothing of what is going on at great depths beneath the surface; and as the chief practical interest is in what is encountered on the surface, we will confine our consideration to that.

Of the action of the moon, or the progress of the tidal wave in the Pacific, our acquaintance is as yet very imperfect, notwithstanding the light thrown upon the subject by Dr. Whewell; but where the currents are strongest the tidal action is usually the weakest. To this source, then, we cannot attribute all action. Heat, which in the case of the atmosphere is the undoubted cause of circulation, will not answer all the requirements. On reference to the diagrams before you, it will be seen that the air and surface-water maintain a very great equality throughout their course; but then the fluids are so different, the one moving with a velocity so many times greater than the other, that their relative differences to the source and acquirement of heat are greatly assimilated.

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* Nautical Magazine, Feb. 1853, pp. 98-100.

The action of the prevalent winds is the chief and efficient source of surface-current action, and a few words on them will be excused. A diagram taken from Lieutenant Maury's recent work will illustrate it, though it does not greatly differ from what Dampier gave as a result of his own experience, or from the previous conclusions of Halley, Young, and others.

The earth in its revolution, having the sun constantly vertical over some portion of the space within the tropics, becomes heated in this zone; and the atmosphere becoming thus specifically lighter, rises and gives place to cooler air rushing below from the regions N. and S. of the tropics; but as the equatorial portions move most swiftly, these are deficient in velocity, and drag as it were on the surface; and from being simply N. and S. winds they become N.E. and S.E. trade-winds. Blowing in this direction they must meet somewhere, and they form a belt of calms or variable winds, of a mean breadth of 6° of latitude. This heated air then rises, and passes off in the exactly opposite direction; that which comes in from N.E. passes off to S.W., and above the trade-winds blowing beneath at right angles to this course. This fact is proved by the passage of volcanic dust, in opposition to the trade-winds. Passing N. and S. it again cools; and having reached the limits of the tropical zone, it redescends in what are here called the calms of Cancer and Capricorn. This warm wind then blows toward the poles, gradually parting with its heat and moisture; till at last reaching the pole quite dried, and at a minimum temperature, it, by its accumulation, rises, and returns towards the tropics to undergo the same process of circulation. Supposing the earth to be of a uniform surface as to the distribution of land and water, these belts of calms and winds would be symmetrical on either side of the equator; but the proportion of land to water in the northern hemisphere is 100 to 154, while in the southern hemisphere it is 100 to 628, according to Professor Rigaud. Yet all the countries in S. latitude are remarkable for the dryness of their climate, and it can be demonstrated that the evaporation of the S. is deposited in the northern hemisphere. From this unequal distribution of land and its effects we have the phenomenon of that line of junction of the trade-winds to the NORTH of the equator (in a mean between 8° and 2° N. lat.), varying with the progress of the sun in the ecliptic, but always characterised in its axis by an enormous deposition of rain; and hence it is known to seamen as "the rains," and is the great barrier to the passage of ships across the line, from its calms and uncertain winds. It will be seen that *the proposed great canal* will lie in this belt, and that during the northern summer months it will be deluged with rain.

There will be no great difficulty in assigning a great effect to the action of wind on the ocean water. The following may be advanced. Its well-known effects in retarding or advancing, increasing or decreasing, the tidal wave, will be one argument;—the storm-wave, which, in a region very distant from its origin, is felt in the form of those terrific "rollers" which set in on the islands of the open ocean; the effect of wind in the formation and direction of waves in the English Channel is well known; the whole of the débris of the coasts being driven to N.W., and accumulating near the Straits of Dover, &c., by the predominant S.W. winds; the accumulation of waves on each other, in the triple or other numerical ratio, superinduced by separate action on previously-formed waves, &c.

That they have an onward progress cannot be denied, it is believed, although this is still, to some extent, an open question; but if a wave can strike a square foot of surface with a force of above 6000 lbs., as has been found by the dynamometer at the Skerryvore Lighthouse, a force equal in weight to a column of granite 60 feet high, or to raise a spout to the height of 130 or 150 feet, as at the Mauritius Souffleur, or spray to the height of 300 or 400 feet, as on the W. coast of Scotland—it must have some onward movement. Without bringing in M. Emy's theory of the *flôt du fond*, which time will not admit of, it may be safely asserted that the wind has sufficient force to cause all known *surface* current action.

The trade-winds, then, setting constantly in one direction, must drive the waters before them to the opposite side of the ocean, causing an accumulation, or head, which theoretically would be, and is practically found to be, of a higher temperature. The question of level is a delicate one; but it is fair to infer that such inevitably must be the case, and the velocity of the Gulf Stream is a great evidence of this, notwithstanding that it runs up-hill as to its base, but could not do so as to surface. If the same action is to be found in the Pacific, and the waters here are to be found accumulating on the western side, and only drawn in on the eastern side from the abstraction, the Pacific level would be several feet lower than the Atlantic, consequently, the canal would have a strong current or a cataract to the westward. But engineering operations have demonstrated that the levels are sensibly the same, and we have therefore to infer that the uniformity is maintained by the presence of that counter-current which has still to be accounted for.

The trade-winds, then, setting on to a zone to the N. of the equator, with more or less tendency towards the N. or S. of E., forcing the waters in a similar direction, they must meet somewhere, and cause an accumulation.

Major Rennell says "the drift-current is the mere effect of a constant or very prevalent wind on the surface-water, impelling it to leeward until it meets with some obstacle which stops it, and occasions an accumulation and consequent stream of current. It matters not whether the obstacle be land, banks, or a *stream of current already formed.*" This equatorial tendency of the drift, it is contended, is the source of this current, which, using the head of water previously formed as a fulcrum, is compelled to revert its direction when not affected by the winds, that is, in the belt of equatorial calms. This is also the true origin of the Guinea Current in the Atlantic, which the meeting of the North African and Equatorial Currents prevents passing to westward.

The form of the main currents, that of a parabola or ellipsis on the axis of 30° N. or S., is similar to that of cyclones, and is also indicative of similar origin.

Panamá and Darien are thus placed in a very *critical* position with respect to those means of navigation most usually employed. The adoption of screw-propellers or other auxiliaries must vastly enhance the utility of the canal. But a correct knowledge of the neighbouring winds and currents is a most important desideratum in the establishment of any commercial navigation in connection with this great undertaking.

Much misapprehension as to the distances to be saved by opening this route prevails in the world. The southern part of New Zealand is at our antipodes; therefore, a straight line drawn on the globe, that is a great circle, will intersect both places, and be of the same length if directed to any point of the compass.

The use of Mercator's projection has drawn attention from the real properties of the sphere, which, it is pleasing to see, are beginning to be felt as imperative, and will be still more so in extended Pacific navigation.

Thus the shortest line between Panamá and Shanghae in China leads into latitude 64° 43′ N., and starts from Panamá about N.N.W., passing between St. Lawrence Island and Behring Strait, while by the chart the apparently shortest or straight line is about W. $\frac{3}{4}$ N. from one place to the other; yet this apparently direct course is 8982 miles in length, the great circle course being 8089½ miles, or just 900 miles less, and is removed from it in one part 2405 miles. Now, if a line of 8982 miles be laid on the other side of this shortest line, it will pass through the whole of North America from S.W. to N.E., and, passing between the North Cape of Europe and Spitzbergen in lat. 75° 29′, long. 24° 17½′ E., across Siberia and then to Shanghae.

This extreme case is cited to draw attention from the Mercator's chart, and the incorrect notions it inculcates.

Supposing a ship could save 500 miles on this route, which she may very readily do, and in the 8400 miles she encounters a current of only 12 miles per day, by using the shortest and best route she may be assisted to the extent of 1200 miles in the single passage, a distance she may lose if these are not attended to.

National Observatory, Washington, May 10, 1853.

SIR—The clipper ship Sovereign of the Seas, McKay, has made such an extraordinary run, that I beg to make it the subject matter of an official report. It is due to builders, owners, and masters, as well as to navigation, that such an achievement should be made known.

This ship is one of the glorious fleet of a "thousand sail" that is voluntarily engaged in making observations for the wind and current charts. She it is, it will be recollected, who, taking them for her guide, made the extraordinary run of 103 days from New York to San Francisco, both crossing the equator in the Pacific, and arriving in port on the day predicted.

Returning from the Sandwich Islands to New York in the remarkably short run of 82 days, she passed through a part of the "Great South Sea," which has been seldom traversed by traders—at least I have the records of none such.

Little or nothing, except what conjecture suggested, was known as to the winds in this part of the ocean. The results of my investigations elsewhere, with regard to winds and the circulation of the atmosphere, had enabled me to announce as a theoretical deduction, that the winds in the "variables" of the South Pacific would probably be found to prevail from the westward with a trade-wind-like regularity.

Between the parallels of 45° and 55° S. from the meridian of the Cape of Good Hope eastward, around to that of Cape Horn, there is no land or other disturbing agent to intercept the wind in its regular circuits; here the winds would be found blowing from the west with greater force than from the east in the trade-wind region, and giving rise to that long rolling swell peculiar to those regions of the Pacific, they would enable ships steering east to make the most remarkable runs that have ever been accomplished under canvas.

The Sovereign of the Seas has afforded the most beautiful illustration as to the correctness of these theoretical deductions.

Leaving Oahu for New York, viâ Cape Horn, 13th February last, she stood to the southward through the belts, both of the N.E. and the S.E. trades, making a course good on the average through them, a little to the W. of S. She finally got clear of them March 6th, after crossing the parallel of 45° S., upon the meridian of 164° W.

The 8th and 9th she was in the horse latitude weather of the southern hemisphere. So far, her run had been good, but there was nothing remarkable in it.

Having crossed the parallel of 48° S., she found herself, on the 10th, fairly within the trade-like W. winds of the Southern Ocean; and here commenced a succession of the most extraordinary days' runs that have ever been linked together across the ocean.

From March 9th to March 31st, from the parallel of 48° S. in the Pacific, to 35° in the Atlantic, during an interval of 22 days, that ship made 29° of latitude, and 126° of longitude. Her shortest day's run during the interval, determined by calculation (not by log), being 150 knots. The wind, all this time, is not recorded once with easting in it; it was steady and fresh from the westward.

In these 22 days, that ship made 5391 nautical miles. But that you may the more conveniently contrast her performance with that of railroad cars and river steamers, I will quote her in statute miles.

Here, then, is a ship under canvas, and with the winds alone as a propelling power, and with a crew, too, so short, the captain informs me, that she was but half manned, accomplishing, in 22 days, the enormous run of 6245 miles (one-fourth the distance round the earth), and making the daily average of 283 statute miles and nine-tenths (283·9). During eleven of these days consecutive, her daily average was 354 statute miles; and during four days, also consecutively, she averaged as high as 398¾ statute miles.

From noon of one to the noon of the next day, the greatest distance made was 362 knots, or 419 miles, and the greatest rate reported by the captain is 18 knots, or 21 statute miles the hour. This is pretty fair railroad speed.

The greatest distance ever before performed from noon to noon on the ocean, was 374 knots (433¼ statute miles), by the clipper ship Flying Cloud, in her celebrated passage of 89 days and 21 hours, to San Francisco, in 1851, and which yet stands unequalled. I say from noon to noon, because from noon to noon was not, with either of these ships, the exact measure of 24 hours. The Flying Cloud was going to the northward and westward, and on the day of her great run she made 4° 46′ of longitude—which, in time, is 19 minutes 4 seconds—that is, her noon to noon for that day, 24 hours, 19 minutes, 4 seconds. On the other hand, the Sovereign of the Seas was steering to the westward, and on the day of her great run, she made 8° 44′ of longitude, which, in time, is 34 minutes 56 seconds—that is, her noon to noon for that day was only 23 hours, 25 minutes, 4 seconds long. Thus the Flying Cloud's run in 24 hours, 19 minutes, 4 seconds, was 433¼ statute miles, and the other 419 statute miles in 23 hours, 25 minutes, 4 seconds.

Reducing these runs each to the performance *pro ratâ*, according to log, for 24 hours, we have for the former ship 427·5 against 437·6 by the latter—that is, the best 24 consecutive hours run by the Sovereign of the Seas exceed the best consecutive 24 hours of the Flying Cloud only by the one-tenth part of a mile.

These two ships are certainly *par nobile*, but the great day's performance of each does not prove the Sovereign of the Seas to be a faster ship than the Flying Cloud.

The Sovereign of the Seas had in her favour that long, rolling swell from the westward, that is peculiar to high southern latitudes, and which helped mightily to heave her along. All seamen who have doubled Cape Horn know what it is. I need not describe it.

It is true that the Flying Cloud on her great day had, during the latter part, strong gales and high seas running; still those high seas were not like that long, rolling Cape Horn swell that comes from the westward with such a heaving force, and which had been chasing the Sovereign of the Seas steadily for ten days.

On the other hand, it may be urged in favour of the latter, that she was short-handed, with foretopmast disabled, and jury topgallant mast. Her abstract log, it should also be mentioned, says nothing as to the force of the wind, the heave of the sea, or the sails set, while that of the Flying Cloud is quite full upon these points.

Though I am unwilling, therefore, to decide against the Flying Cloud as to the greatest day's run ever made, it is clear that her competitor has borne off the palm as to the length of time for which she has kept up her great speed. Her log stops May 3rd, latitude 33°, 15′ N., 432 nautical miles in a straight line from Sandy Hook.

Taking it therefore for the 79 days for which she gives it, and stating the distance by straight line from her place at noon of one day to the noon of the next, it appears that her daily average was 222·7 statute miles, making the whole distance sailed during the interval to be 17,597 statute miles, which gives for canvas the remarkable achievement of accomplishing a distance more than two-thirds of that which it requires to encircle the earth, at the rate of 9 miles and upwards the hour, for 1896 consecutive hours.

As I write this, the abstract of another ship the Comet, E. C. Gardner, from San Francisco to New York, is received. She, too, has made the passage in 83·3 days, sailing during the interval 17,496 statute miles, and averaging 210 miles a day. She, however, except merely by doubling Cape Horn, did run through the region of the trade-like winds and heaving swells of the South Pacific, which favoured the Sovereign of the Seas to such an extent; and therefore no fair comparison can be made as to the relative sailing qualities of these two ships.

There is another circumstance, however, connected with this voyage of the Sovereign of the Seas, which is worthy of attention, for it is significant, and a fact illustrative of the revolutions in the way of business which are being quietly wrought by the time-saving devices of the age. This splendid ship, after unloading her cargo in California, was sent to glean after our whalemen, and she came home with oil gathered from them at the Sandwich Islands.

This adventurous class of our fellow-citizens resort there in such numbers that the fees annually paid by the government for the relief of the sick and disabled seamen there, amount to upwards of 50,000 dollars.

Now, if the Pacific Railway were built, the thousands of American seamen, and the fleets of American whale ships, that annually resort to those islands for refreshment and repairs, would resort to California. There they would be in their own country; the oil would probably be sent home on railway, instead of by clipper ship, and all the advantage of refitting so many ships, of treating and recruiting so many men, would inure to the benefit of our own-citizens. Respectfully,

(Signed) M. F. Maury,
Lieutenant U. S. Navy.

XX.—*Chusan, with a Survey Map of the Island.* By Sir J. F. Davis, Bart., F.R.S., F.R.G.S.

Read June 13, 1853.

The importance of this island was sufficiently demonstrated by its capture on two successive occasions by a British force, and its retention (on the last) for a period of four years, as a guarantee for the fulfilment of the stipulations of the treaty with China. If any additional considerations could augment the importance of Chusan, it would be the vicinity of the position to Japan, and its intervening between the mainland of China and that other nation which once actually occupied it, and which is fast becoming an object of interest and speculation to the civilized world. Whatever may be the result of the pending American expedition to Japan, it is certain that the new current of adventure, setting westward across the Pacific, must find Japan, with Chusan, the first outposts of the Asiatic Continent in that direction; and Christian states must inevitably be involved in relations, amicable or otherwise, with those hitherto secluded regions. The object of this paper is to illustrate a Map of Chusan, completed by actual survey during our last occupation of the island, when Brigadier (now Sir Colin) Campbell had the command, and to add such other details as could be collected from various sources (chiefly through Dr. Gutzlaff) in several visits to the spot. The last was